Frequency Conversion For Long Distance Quantum Communications

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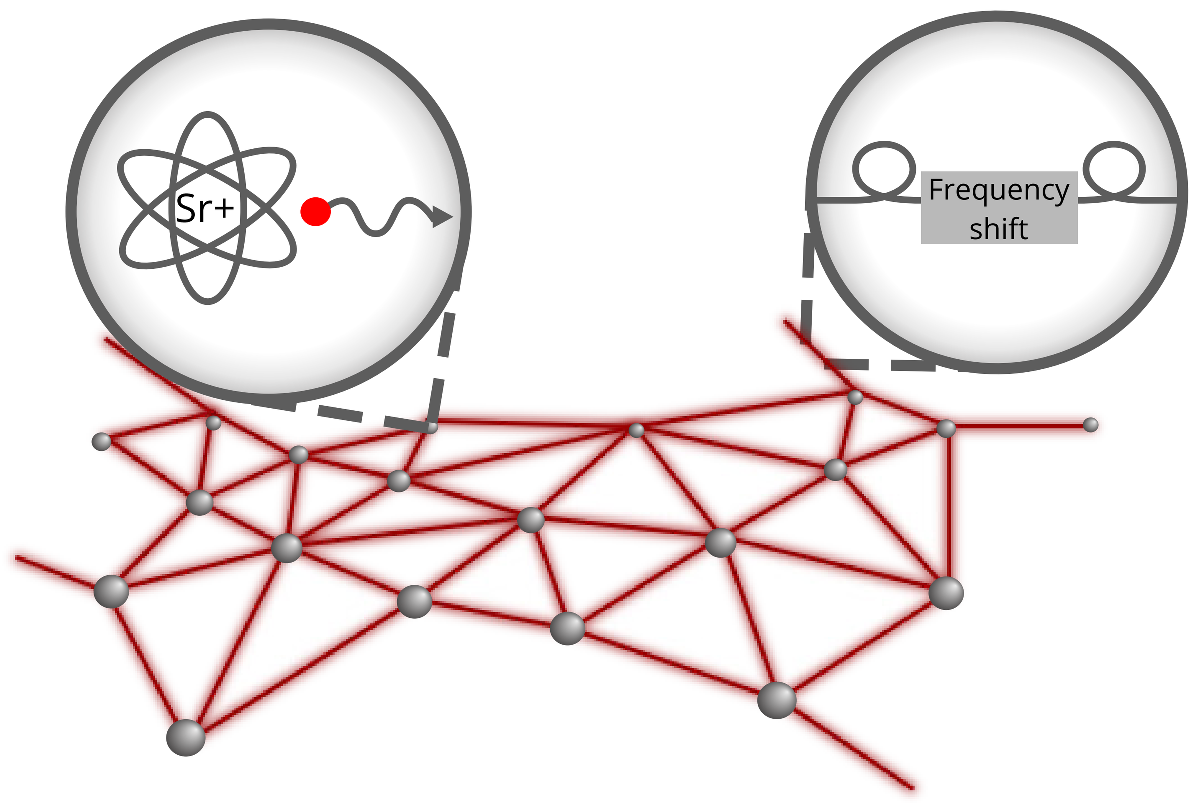
NQIT Networked Quantum Information Technologies

Abstract

Quantum comunications require a long distance quantum network, consisting of nodes that are optically linked to each other. Each node consists of an ion trap, that stores information in quantum states (qubits) which is distributed between nodes in fibre. Presented here are efforts to create a reliable source of single photons to emulate the output of these ion traps, done using parametric down conversion (PDC) in a non linear crystal.

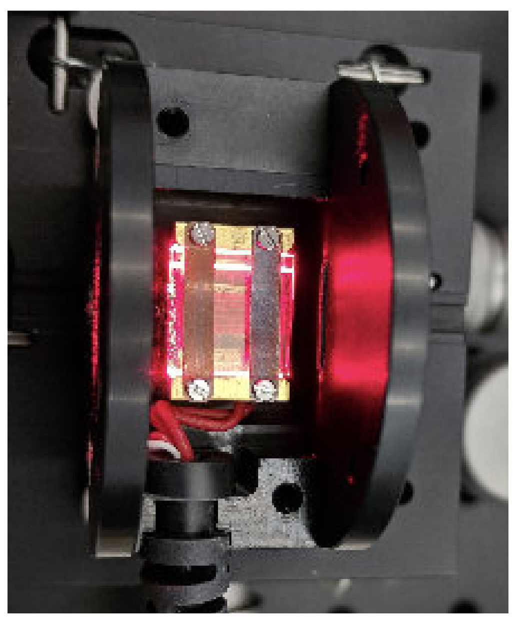
Quantum Networks

Strontium ion traps are used to store and relay quantum data with a dominant emission wavelength of 422nm, which has poor long distance propagation in silica. By placing the ion in a cavity, it can be made to emit at 1092nm. this will enable better long distance transmission in fibre

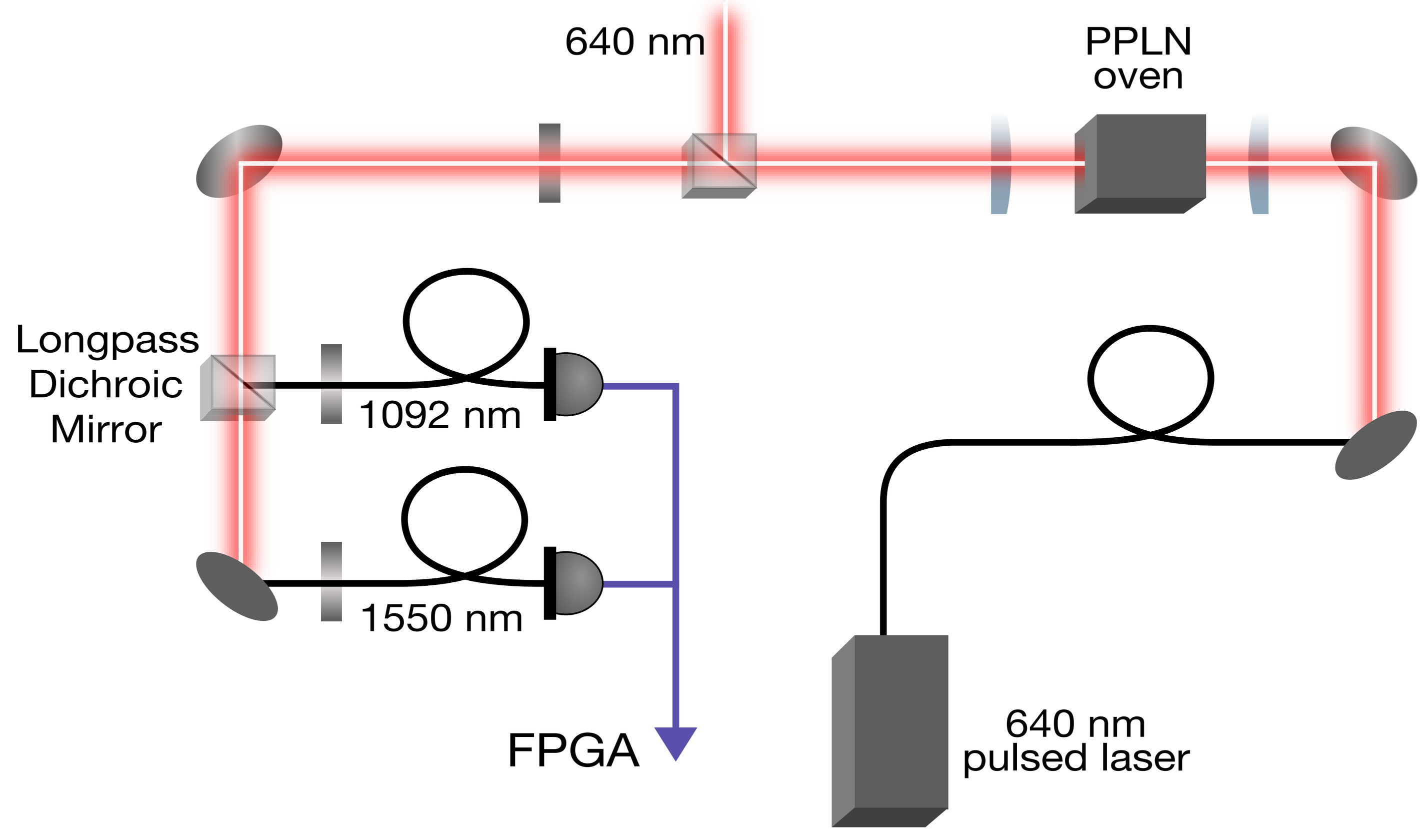


Experimental Setup

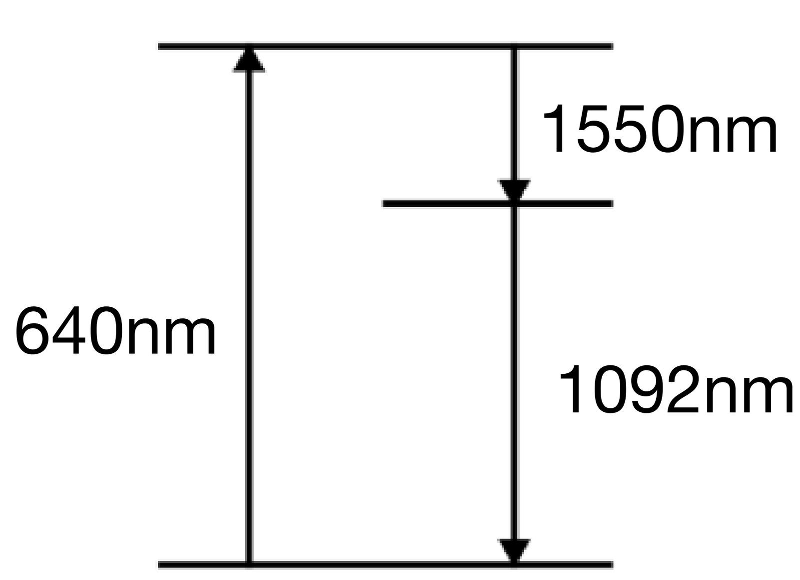
A periodically poled lithium niobate (PPLN) crystal was used to facilitate the PDC process. PPLN is a nonlinear material that demonstrates temeperature dependent birefringence, allowing quasi type-0 phase matching. This means we are able to produce co-polarized photon pairs



Below is a diagram of the experimental setup used to create photon pairs. It features a PPLN crystal and oven on a translation stage, used to arange the crystal such that the beam is focused into a grating with a particular size to adjust the phase matching of the process.

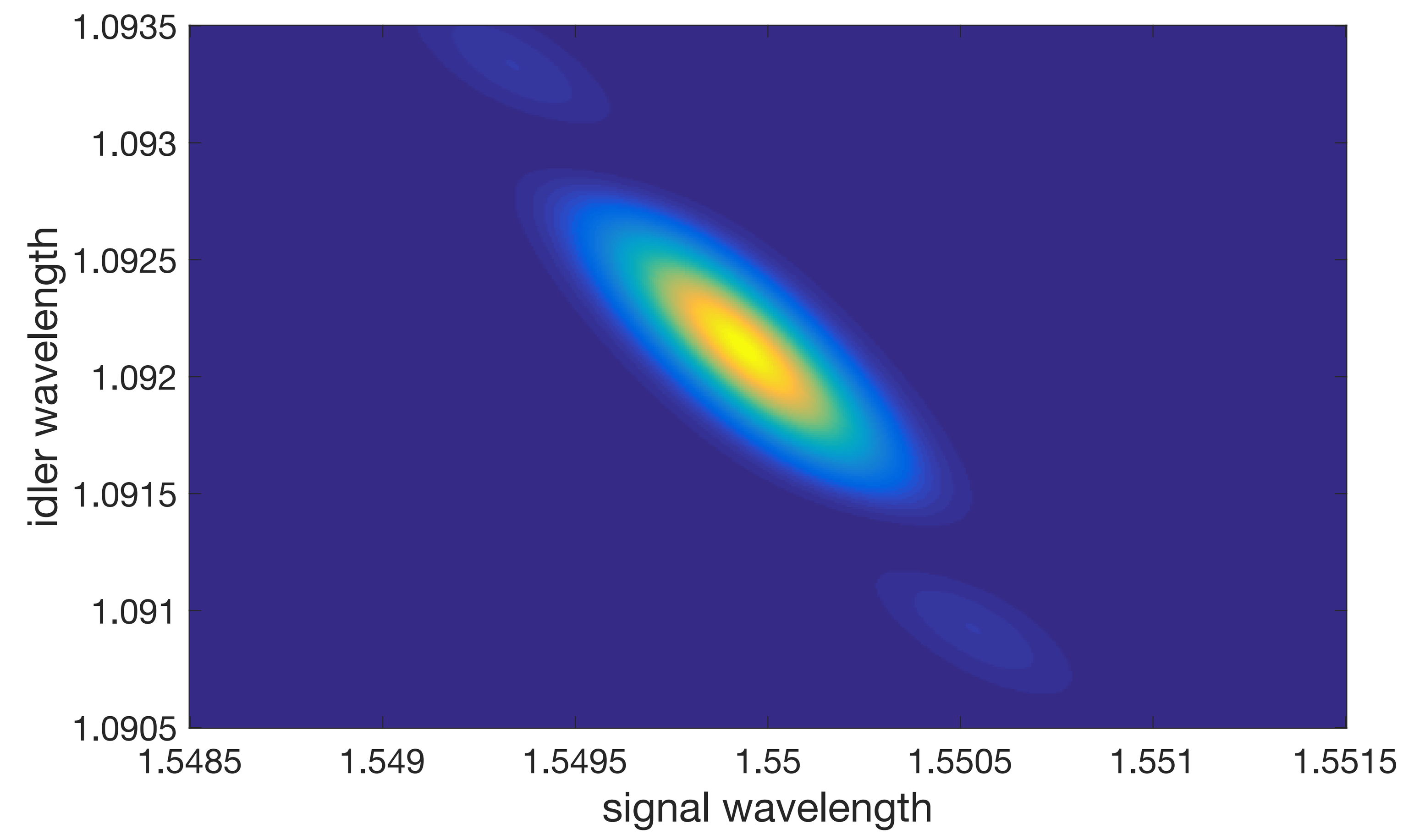


Parametric Down Conversion

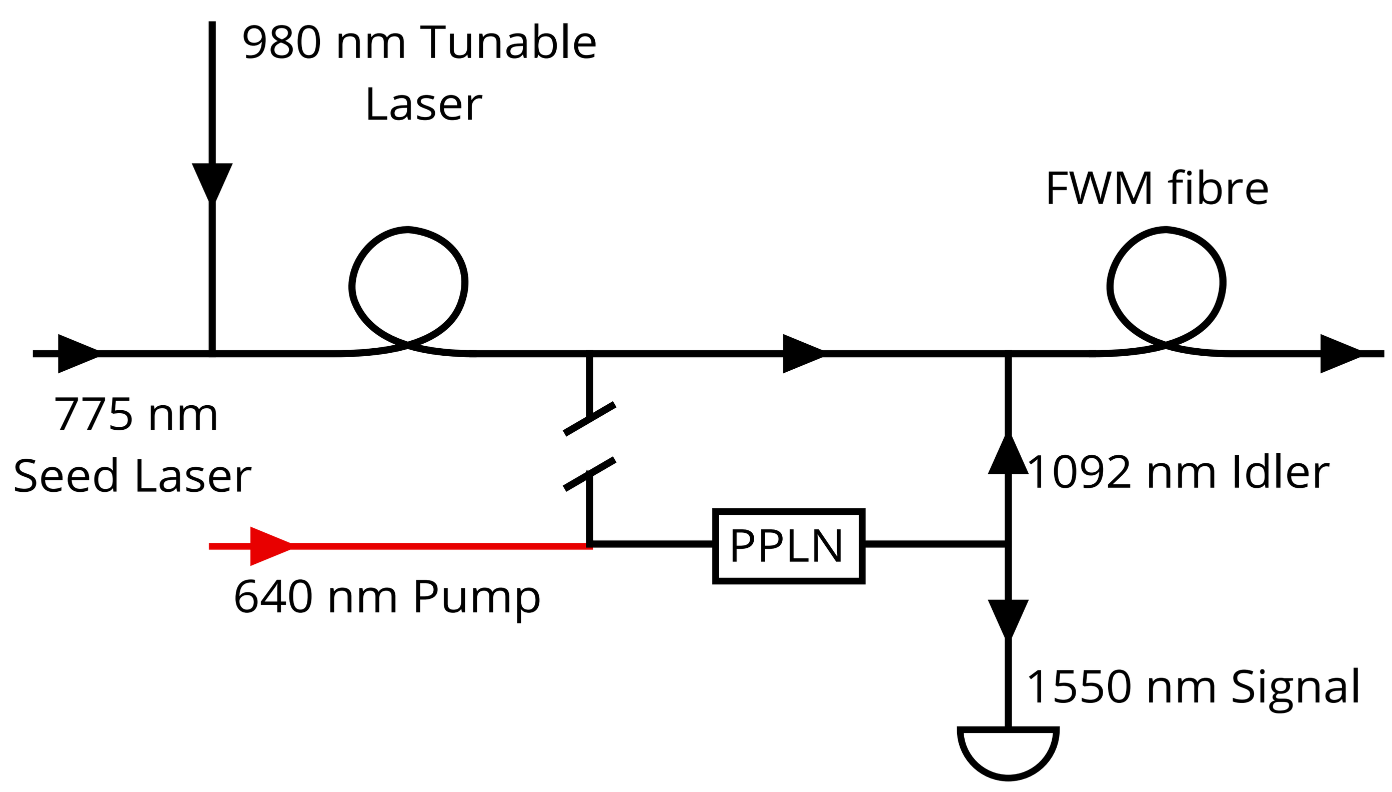


Using a 640nm pulsed laser as a pump source for the PDC process will produce photons at 1092nm (idler) and 1550nm (signal). The signal photon can be routed to a detector to measured for coincidence counts, determine the pair production rate, and characterize the PDC source.

The figure below shows the joint spectral intensity of the possible photon pairs. It shows high correlation around the desired wavelengths meaning the bandwidth of the produced wavelength will be narrow.



Future Work



For long range data transfer, it would be more effiecient to use photons at 1550nm therefore this source will be integrated with (FWM) fibres to demonstrate conversion of photons from 1092nm to 1550nm. Since the 1092nm photons produced will have some bandwidth the tunability aids in producing photons at the end of the FWM fibre that are closer to 1550nm. This will give even better transmission and allow communication over distances to the order of tens of kilometers.